



UNIVERSITI PUTRA MALAYSIA

**PATTERNS OF ADVANCED COMPUTER APPLICATIONS
IN SINGAPORE**

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ABSTRACT

PATTERNS OF ADVANCED COMPUTER APPLICATIONS IN SINGAPORE

This thesis analysed the state of practice in Operations Research (OR) and Management Information Systems (MIS). Special emphasis is placed on the role of computer technology in these advanced application areas.

A major finding of the research reported in this thesis is that both OR and computer-based MIS were used only by approximately a quarter of the survey samples.

Operations Research was mainly applied to operational and tactical problems on an ad hoc basis by various functional areas. The majority of the techniques were used regularly only by a third of the users. It was only within the last five years that most of the OR techniques were implemented. Overseas headquarters and associates were the most frequent source initiating the use of operations research in Singapore. In contrast to practices in the West, OR has not suffered from lack of top management support.

Management-oriented information systems were found in less than half of the electronics firms. An Information Systems (IS) Typology was developed to classify information systems of various degree of sophistication. Using this conceptual scheme, the analyses revealed that number of employees, product type, nationality, age, market and equity capital influenced the sophistication of information systems. The state of practice and development trends in computer-based information systems were also examined. The survey found that the use of computers in information systems has been a recent phenomenon and computer impact was mainly felt in lower level management activities and in the accounting and logistics areas. In general, systems management activities were under the jurisdiction of the Accounting/ Finance Department - traditionally the predominant location of systems activities.

It is not expected that there will be large scale expansion in computer-based OR and MIS in the near future. The majority of OR techniques and applications will continue to be financial in nature, based essentially on an extension of the accounting system to generate information for management decision support. A general direction towards developing management-oriented information systems was identified in this research.

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Finally, my inadequate words of gratitude must go to my most influential professional and personal mentor: *Dr. Tan Boon Wan.*

Han Chun Kwong

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To my family, to whom I owe everything, and
to the great author of these verses:

*If I speak in the tongues of men and of angels but
have not love, I am a noisy gong or a
clanging cymbal.*

*And if I have prophetic powers and understand mysteries
and all knowledge, and if I have all faith,
so as to remove mountains, but have not love,
I am nothing.*

*If I give away all I have, and if I deliver my body to
be burned, but have not love, I gain nothing.*

*Love is patient and kind; love is not jealous or
boastful;*

*It is not arrogant or rude. Love does not insist on
its own way; it is not irritable or resentful;*

It does not rejoice at wrong, but rejoices in the right.

*Love bears all things, believes all things, hopes all
things, endures all things.*

*Love never ends; as for prophecy, it will pass away; as
for tongues, they will cease; as for knowledge,
it will pass away.*

*For our knowledge is imperfect and our prophecy is
imperfect;*

But when the perfect comes, the imperfect will pass away.

*When I was a child, I spoke like a child, I thought like a
child, I reasoned like a child; when I became a
man, I gave up childish ways.*

*For now we see in a mirror dimly, but then face to face
Now I know in part; then I shall understand
fully, even as I have been fully understood.*

*So faith, hope, love abide these three, but the greatest
of these is love.*



GUIDE TO THE READER

The method used in this thesis to acknowledge references involves listing a reference number in brackets. References are numbered according to the alphabetic sequence of the author's surname or principal author's if more than one, and are listed in the Bibliography. This approach has been taken to aid clarity of presentation.

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CHAPTER 1

INTRODUCTION

In broad, general terms, the objective of this thesis was to study patterns of advanced computer applications in management. In other words the objective was to describe the tendencies in adoption of computer technology in advanced applications like Operations Research (OR) and Management Information Systems (MIS), with a view to providing useful insights for those interested in mobilising computer resources in these areas as well as providing a base for those interested in monitoring the progress in the use of these managerial tools over time.

It was in 1954 at the General Electric's Appliance Park in Louisville, Kentucky USA, that the first computer was installed for a business application : processing of payroll. Payroll processing by computer, which was a revolutionary idea in 1954 is now considered a rather routine application. Today the frontiers in business computer applications are in the fields of Operations Research and Management Information Systems. Indeed many of the Operations Research techniques now regarded as standard and the concept of Management Information Systems as a managerial decision support tool would be impractical to implement without modern computers. By generating practical uses for increasingly larger and faster machines, Operations Research and Management Information Systems have both benefited from and contributed to the explosive growth of computer capability that has occurred over the past two and a half decades.

In a 1979 survey of computers conducted by the Singapore Ministry of Science and Technology (38), it was found that there were 241 establishments with a total of 301 computers. During the 1975-79 period, the average annual rate of computers installed was 54 units per year compared to 6 units per year during 1970-74. Size of the computers varied from 2K Bytes to 4096K Bytes, with medium-sized computers in the range of 16-128K Bytes forming the largest (61%) category. The aggregate computer operating time for the 301 installations was 57196 'walk clock' hours giving an average of 190 hours per computer. This was made up of 37160 (65.0%) hours with batch mode and 20036 (35.0%) by on-line mode. Out of a total of 57196 hours of computer operating time (monthly), 58% were for administration, 26% for operations and production, 6% taken up for research and statistics and the remaining 10% for miscellaneous activities. A finer classification of activities revealed that the main areas of application were financial accounting (18.2%), banking (16.8%), billing (15.4%), inventory control (13.0%) and maintenance of records (6.2%). There was very limited usage of computer in applications such as statistical analysis (3.1%), management accountancy, planning and control (2.9%), information services (1.7%), data management (1.3%), research (0.8%) and forecasting (0.6%). (See Appendix A for details of computer utilization).

The purpose of the Ministry survey was however to generate statistical data on computer installations and not to specifically evaluate the impact of computers on the job of managing. Therefore it is imperative that a program of research be carried out to study the use of computers in operations research and management information systems, which have been hailed as working tools that can better harness the computer power to aid the management process.

* * * * *

The remainder of this thesis will be in three parts:

The first part (Chapters II and III) will include a review of the literature on the state of practice of OR and MIS in the West, a description of the conceptual scheme that was used to interpret the state of practice of MIS, and a description of the procedures that were used to gather field data.

The second part (Chapter IV and V) will comprise the analysis of the state of practice of OR and MIS.

The last part (Chapter VI) lists the major findings and implications.

CHAPTER II

A REVIEW OF THE LITERATURE

The purpose of this chapter is to describe some of the predominant streams of research on the practice of Operations Research and Management Information Systems that had developed in the West. It was in the West that much of the development and implementation of Operations Research and Management Information Systems had taken place, and from the West are these technologies transferred to Singapore.

2.1 Some Pertinent Research on Operations Research

Although most pertinent studies of the adoption of operations research techniques have been conducted in the United States, a few have been reported in other countries, notably Great Britain, Sweden and Australia.

Here, in chronological order is a resume of the findings:

- (1) In the United States, in 1958 Hovey and Wagner (15) found that 61 out of 90 respondent companies were using some form of operations research. The sample comprised public and private companies but excluded private consulting and governmental organizations. They found the percentages of positive responses

indicating actual operations research applications were: forecasting 57%, production scheduling 47%, inventory control 45%, quality control 33%, transportation 26%, advertising and sales research 20%, maintenance and repair 16%, accounting procedures 16%, plant location 15%, equipment replacement 15%, packaging 13%, and capital budgeting 11%.

- 2) In Great Britain in 1959, Rivett (36) randomly sampled members of the Operational Research Society. One hundred questionnaires were distributed, of which seventy-six were returned. In addition, Rivett obtained answers to specific questions from 180 senior operational research workers. He found the main problem areas in which operational research work was being carried out were finance, inventory, production and transportation. He went on to comment that, at that time, the fields of marketing, purchasing and human problems still awaited exploration by operational research workers.
- 3) In the United States, in 1965, Schumacher and Smith (37) sent mail questionnaires to 168 companies selected from Fortune's "top 500". Forty-nine (75%) of the sixty-five respondents stated that they used operations research techniques - with the two most frequently reported areas of application being inventory control

and production scheduling.

- 4) In the United States, in 1966, Vatter (42) sent 3500 mail questionnaires to all members of the Financial Executives Institute. The technique reported most widely was Critical Path Scheduling (PERT) with 226 out of the 360 respondents (63%) indicating at least some use of network models for schedule planning and control. The next most frequently reported techniques were inventory models and linear programming. Vatter also appraised the results that users had obtained with their use of these techniques. He found that CPM/PERT had been found to be most useful ... but disappointingly only 34% of those who had used the technique, reported good results.

- 5) In order to extend the findings of the 1964-66 U.S. survey, conducted by their research team (33), Radnor and Neal (34) in 1970, conducted a field survey of 108 firms, selected on the basis of having operations research/management science activities. As in the previous survey, this survey concentrated on large companies. All but 16 were listed in Fortune's largest U.S. corporations. They found that capital-intensive industries, such as petroleum/chemical, tended to utilize OR/MS to a greater extent than

labour intensive organizations, such as engineered products and merchandising. They suggested that this would point, tentatively, to major change being easier to introduce to a machine-oriented environment than it is to one dominated by people considerations. They found, just as they had in 1964- 66, that bridging the communication gap between OR/MS personnel and the rest of the organisation was very much a problem and an inhibitor to the adoption of operations research techniques.

- 6) In Sweden, in 1973, Lönnstedt (18) studied twelve companies quoted on the Stockholm Stock Exchange that he knew to be using operations research techniques to a reasonable extent. He found that among the 107 projects studied, network planning (37%), simulation (27%), Linear programming (16%) and inventory theory (8%) were the most widely used techniques.

- 7) In the United States, in 1975, Gaither (13) surveyed 500 companies selected at random from manufacturing firms with 250 or more employees in Arkansas, Colorado, Kansas, Missouri, New Mexico, Oklahoma and Texas. He found that 133 out of the 275 responding firms (48%) used operations research techniques. 33.5% of the firms used PERT; 32.4% CPM; 27.7% linear programming; 26.9% exponential smoothing and regression analysis;

25.1% computer simulation and 14.2% queuing theory. The using firms ranked the manufacturing problems analysed most by operations research techniques as (1) production planning and control, (2) project planning and control, and (3) inventory analysis and control. Only slight variations in these rankings were observed across all firm size and industry group classes. The overall results achieved by operations research personnel were rated good to very good by nearly 80 per cent of the using firms; another 11 per cent rated the results as excellent. No firm rated the results as poor. The problems encountered in using operations research techniques were ranked as 1) production personnel are inadequately trained, 2) competent personnel with quantitative training are scarce, and 3) staff personnel do not sell these approaches and solutions.

- 8) In Sydney, Australia in 1978, O'Leary and Cooke (30) surveyed 42 companies and governmental institutions which had at least one employee who was a member of the Sydney Branch of the Australian Society for Operations Research. They found that 95% of the sampled organizations were using at least one operations research technique. On average each of the organizations that had adopted operations research as a working tool was using three techniques with

banks, government departments and conglomerate companies the most prolific users.

Production departments were reported as being the most frequent users and the techniques which had found most favour were computer simulation, linear programming, regression analysis, financial forecasting and PERT. O'Leary and Cooke noted that the computer simulation models were used routinely by only 5% of their users, linear programming by 20% and regression analysis by 22%; and that there existed a communication gap between operations researchers and other managers in their organizations. They concluded that their findings reinforced John Little's 1970 Boston lament (17) that *"the big problem with management science models is that managers practically never use them"*.

It should be noted that, in all of the above studies, except those conducted by Vatter (42) and Gaither (13), the researchers biased their samples so that it was likely they would encounter companies that had adopted operations research techniques.

2.2 Some Pertinent Research on Management Information Systems

A survey of the literature reveals that MIS texts and articles deal with computer based information systems. In fact the common thread that at once unifies but also subverts the MIS literature is computer based information systems.

A study reported by Churchill et al. in 1969 (3) involved interviews with users, managers, and computer department management in 12 companies. Based on the interviews, the researchers concluded that the present information systems literature presented a far more advanced picture than that which actually existed. Computers, as was predicted, have achieved much in clerical operations, but they have been used less frequently in other areas. There was little or no impact from computers on higher levels of management in this study. Companies did appear to be moving toward more management-oriented systems. The new systems being planned in the companies were wider in scope than existing systems, and these new applications integrated more departments and crossed more functional boundaries.

In a 1974 study by Lucas (19), seven manufacturing firms provided data on their information systems. The study include applications in which computers are most frequently used in manufacturing. There were systems for production control, financial accounting, order processing, and payroll and personnel applications, and one system for planning. By identifying

the purpose and use of each system, Lucas found that about 75% of the reports generated fell into the "transaction processing" category because they represent systems that primarily automate clerical processing activities, much the way assembly lines automated manufacturing.

In 1975 Bartezzaghi et al (2) conducted a study to explore the computerization phenomenon in a small sample of 24 manufacturing firms in the Milan area. One of the main objectives was to describe the state of business and administrative computerization in the manufacturing industry. They found that the average state of computerization was approximately that of the "Second Stage" level of Richard L.Nolan's model (27); with the following order of level of automation (most automated to least automated);- accounting or operational procedures, statistic procedures, control procedures, and decision-oriented procedures.

In a subsequent 1976 study, Lucas (19) examined the implementation of computer-based models in a sample of companies. Essentially here the planner uses a computer language to construct a representation of the firm. The resulting model is run on a computer to predict the outcome of various decision alternatives. Such a system has the potential to support strategic planning in the firm, but only 4 out of 18 companies used the models for this purpose. The other 14 firms used their models to take immediate action on problems, generally at the operational control level.

The picture that emerges from these studies is one of systems which have limited impact on managers. Most of these systems have focused on structured operational control decisions and transactions processing.

A more recent picture and valuable insights into the state of practice in computer-based information systems applications as well as the management of EDP activities can be inferred from Richard L Nolan's 1979 "Six Stages of EDP growth" model (29). Nolan traced the pattern of development of EDP installations and segmented their growth history into six stages, each with unique characteristics. During stage 1, Initiation, the first computer systems are installed and the use of computer grows gradually in the organization. During stage 2, the number of applications expands rapidly and machine capacity becomes saturated. New systems and enhancements drive the DP budget upward, creating a crisis for management. In Stage 3, management attempts to control expenditures for computing often through a moratorium on new applications. During this stage the use of computers increases at a decreasing rate. Stage 4 features the rise to control of users of DP programs. In stage 5, data administration is introduced. During stage 6, Maturity, the applications portfolio is completed; and its structure "mirrors" the organization and the information flows in the company. According to Nolan, no companies have yet entered stage 6 although a few are approaching it; and a great

many have entered the intermediate stages. A set of benchmarks were developed for identifying a particular stage of EDP development. The first-level benchmarks are DP expenditure and DP technology, while the second-level benchmarks are applications portfolio, DP organization, DP management and user awareness. The predictive value of Nolan's model cannot be underscored. Having determined where the company stands in the development of its DP function, Management will be able to structure its DP strategies and future development plans consistent with overall company strategies.

While not attempting to adapt Nolan's model to the analysis of the spectrum of information systems covered in this survey, the status of computer-based information systems were generally assessed with reference to the Stage Hypothesis.

CHAPTER III

RESEARCH OBJECTIVES & METHODOLOGY

The overall objective of this research program was to study patterns in advanced computer applications. That is, the objective was to study the practice of Operations Research and Management Information Systems.

Specifically the objectives were :-

- 1) to determine the extent to which Operations Research and Management Information Systems have been used to support the managerial decision making process.
- 2) to identify management and organizational issues pertaining to the practice of Operations Research and Management Information Systems.

To achieve these objectives two surveys were carried out. Their specific objectives and methodologies are described separately below.

3.1 Objectives & Methodology of OR Survey

The Operations Research discipline began in the West during World War II. Many strategic and tactical military problems were successfully solved by operations research methods. After the war, many of the scientists who had been active in the military OR groups turned their attention to the possibilities of applying a similar approach to civilian problems.

Since post World War II, managers in the West have been exposed to an increasing number of OR techniques which can help them to make better decisions. However, have managers in Singapore taken advantage of this established kit of tools as aid to decision making? And now, more than 35 years since its inception in the West, do Singapore managers adopted an OR approach to the analysis and solution of their management problems, an approach which has been variously defined as "the systematic application of quantitative methods, techniques and tools to the analysis of problems involving the operation of systems" (5) and "the construction and application of mathematical models for solving recurring management problems that can be best handled by computers" (40)? Or do they basically rely on experience, intuition, common-sense and good judgement? More specifically, as far as this survey was concerned, what was the state of practice of Operations Research by organizations with computer installations in Singapore at the close of 1981?

3.1.1 Objectives

The specific objectives were to determine, with respect to computer installations in Singapore:

- 1) The extent of adoption of operations research techniques and the management decision areas to which the techniques were applied.
- 2) How frequently the techniques were used, the functional areas using them and the organizational location of operations research activities.
- 3) The extent to which computer hardware and software availability has encouraged the use of operations research techniques.
- 4) Source origination of the use of operations research techniques and qualifications of operations research personnel.
- 5) The perceived practical value of operations research techniques and implementation problems.
- 6) Reasons for non-usage of operations research.
- 7) The prospects for Operations Research in Singapore.

3.1.2 Sample Selection

A 30% sample stratified proportionately on industry sector was randomly selected from the directory of the Asian Computer Yearbook 1981/82. A package consisting of a typesetted questionnaire (See Appendix F for actual questionnaire used), a prestamped return envelope and a cover letter personally addressed to either the EDP manager or the Chief Executive was despatched during October 1981. This was followed up by telephone and personal interview to obtain the final sample of 106 organizations.

The responding organizations could be classified according to activity as follows :-

<u>Major Activity</u>	<u>Number</u>
Distribution, Trading & Hotels	21
Banking, Finance & Business Services	18
Manufacturing	17
Consultancies & EDP Services	15
Transport, Storage & Communication	10
Engineering & Construction	6
Education	3
Agribusiness	2
Public Administration	2
Petroleum & Energy	2
Others	<u>10</u>
Total	<u>106</u>